PROGRESS REPORT ON SMOKE TOXICITY RESEARCH IN THE U.S.

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The three years since the 11th meeting of the UJNR Panel on Fire Research and Safety have seen remarkable progress toward resolution in this field. They have also seen a major drop in research into fire toxicology. The field of smoke toxicity can be subdivided into three areas, which are discussed as follows.

1. Measurement of the impact on people (*via* surrogate animals) of the smoke

The first of these areas will be brought to resolution in the near future. NIST has developed a methodology for obtaining useful lethal toxic potency data for use in fire modeling.[1] This method uses an advanced version of an apparatus originally developed for the National Institute of Building Sciences by the SouthWest Research Institute. The data from the apparatus has been verified against real-scale room fire tests, and the results have been analyzed in the context of the threat to life safety. The method is under consideration by NFPA and ASTM. A paper on this method appears elsewhere in this program.

Little else is going on in the measurement area. One exception is that the University of Pittsburgh team is working on a modified version of their apparatus. In this, the tube furnace has been replaced by a Cone Calorimeter heater.

The NIST research on the kinetics of CO absorption into and removal from the bloodstream is near completion. These results will enable a more accurate depiction of the disabling of people as they approach the fire zone, move from room to room, etc. Completion of this work is expected soon.

The U.S. Navy has been conducting studies of the effects of very low levels of CO on the mental acuity of sailors. No reports have been published to date.

2. Determination of levels of human exposure to the gases in fires

This is being worked as part of the fire modeling and full-scale fire test area and needs no further discussion here.

3. Data and models for predicting the generation of toxic gases

The research in this area focusses on CO formation. Of the major toxic gases, it is both the most important and the one most complex in its generation. Carbon dioxide is generated roughly in proportion to the mass burning rate of the fuel. Hydrogen chloride and hydrogen bromide (from halogen-containing fuels) can be assumed to be generated in room fires in roughly the same manner

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they are emitted from samples burned in the Cone Calorimeter. There is no research effort underway to predict the yields of other toxicants, such as HCN.

Carbon monoxide can be produced directly in a fire plume. For this reason, several groups are studying the chemistry and dynamics of diffusion flames.[2] Recent work indicates that, while there is some effect of vitiation on CO yield [3][4][5][6], the yields themselves are too small (generally < 0.05) to account for the high values (several percent) observed in post-flashover fires.

A hypothesis has been advanced that the global equivalence ratio, the normalized fuel/air ratio in the upper layer of the room, is the principal predictor of CO concentration, and a model has been developed for this phenomenon.[7] Kinetic calculations by Pitts [8] have shown that GER is the controlling factor in CO yields only if the upper layer temperature is too low for any subsequent reaction. These conditions coincide with pre-flashover fires only; and in the United States, post-flashover fires produce most of the deaths from smoke toxicity. This will be discussed in a later paper at this meeting.

Research is thus being conducted in full-scale and reduced-scale enclosures to determine the factors that can result in high CO yields. Mulholland (reference 6) and Roby *et al.* [9] have found that CO yields of ≈ 0.2 g_{CO} per g_{fuel} result from post-flashover fires of a diversity of fuels in a range of compartment geometries. Recent work by Pitts *et al.* has shown that very high CO yields can result from the anaerobic pyrolysis of oxygen-containing fuels in the upper layer of a compartment after flashover.[10] This will also be presented at this meeting.

In summary, there is reasonable expectation that there will be a U.S. standard test method for determining smoke lethality data by the 13th UJNR meeting. It is also likely that our ability to estimate carbon monoxide yields will be well-advanced by that time.

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